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ABSTRACT

The Open University, founded in 1969, has already become the largest university in Britain in terms of the number of undergraduate students, with an enrollment of 41,000 in 1973. This paper is concerned with three areas of discussion: (1) the number of teachers studying Open University courses; (2) the courses available or planned in science and technology; and (3) the integrative features of Open University science and technology courses. The survival rate of teachers appears to be marginally higher than that of other occupational groups, with teachers comprising 42 percent of the continuing students in 1972. A chart outlines the courses available in science and technology together with the credit awarded for each course. Many of these courses are multidisciplinary in content, integrative in approach, and relate the subject to the social context. The author concludes that science and technology courses of the type being taught in the Open University could make a significant contribution to the education of teachers of integrated science. (JR)

Open University courses in science and technology applicable to the education of teachers of integrated science

by

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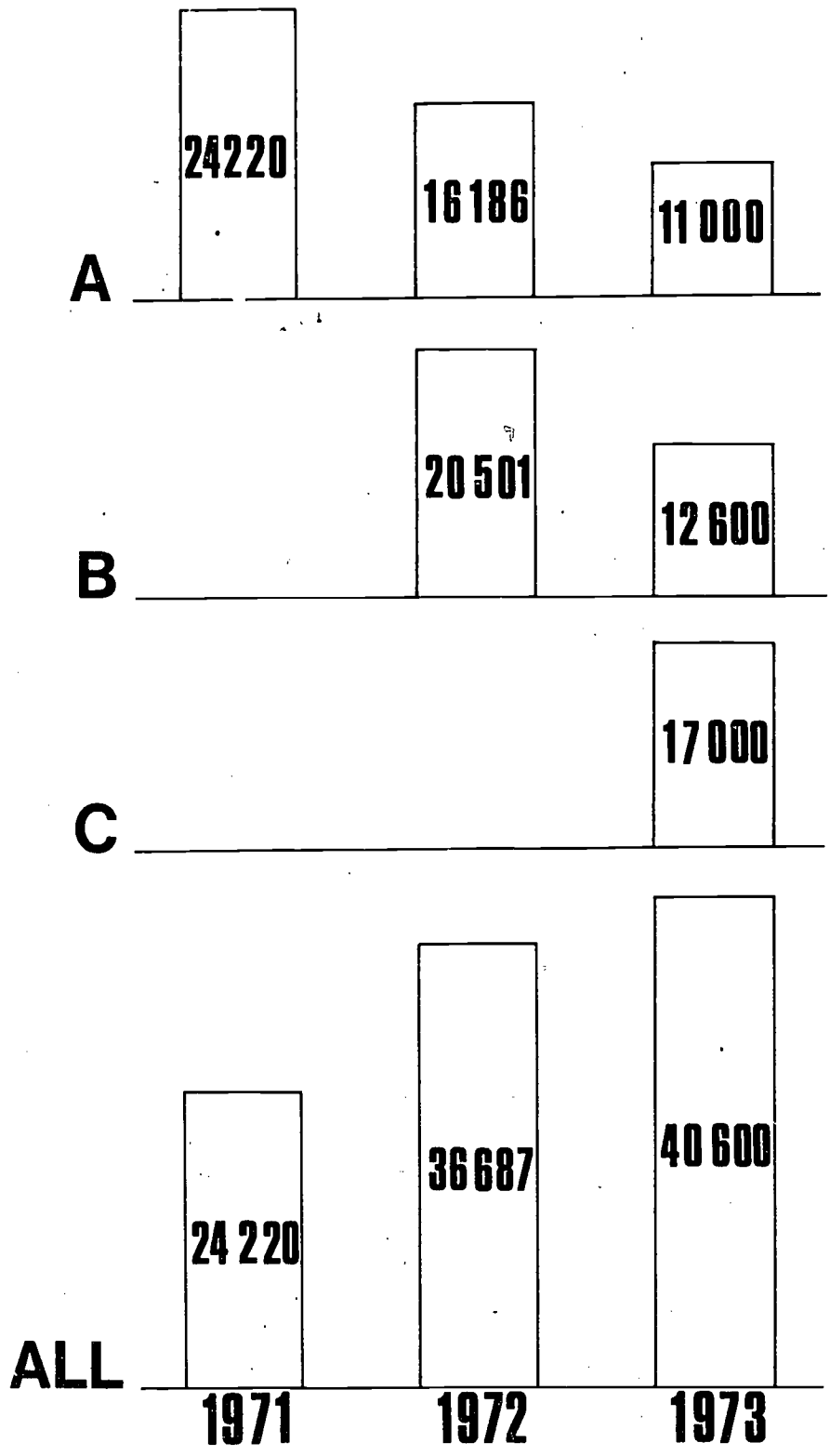

Figure 1 : Numbers of Students in Open University Undergraduate Courses 1971-1973

A : 1971

B : 1972

C : 1973

Introduction

It is clearly not possible in such a short paper as this to go into the subject in any great detail.

It is accordingly restricted to the discussion of three questions:

1. How many teachers are studying Open University courses?
2. What courses in science and technology are available or planned?
3. What are the 'integrative' features of Open University science and technology courses?

Participants at the Conference will have the opportunity to study Open University course materials - printed texts, home experiment kits, television and radio components. This paper will not be presented formally at Plenary Session P3. It will be taken as read. Instead, a short film about the Open University will be shown, followed by informal discussion.

1. How many teachers are studying Open University courses?

The Open University was founded in May 1969 and admitted its first twenty-four thousand students in January 1971. Some sixteen thousand of these students continued their studies in 1972 and a further twenty thousand new students were admitted. In January 1973, a further 17 000 new students were admitted. With 11 000 of the 1971 intake and 13 000 of the 1972 intake continuing, this has brought the undergraduate population up to a total of 41 000. See Figure 1. Meanwhile, the first nine hundred students, all of course from the 1971 intake, have already qualified for their ordinary BA degree. The number of graduates per annum is expected to rise rapidly over the next two or three years and reach a steady figure of 4-5 000 by 1976.

Thus the Open University has, in only a very few years since its foundation, already become the largest (in terms of numbers of undergraduate students) in Britain.

As might be expected, for all three years teachers have constituted the largest single occupational group in the student intake. See Table 1. But their proportion has declined significantly since the first year.

TABLE 1

TEACHERS IN THE JANUARY INTAKE

1971		1972		1973	
Number	% of total	Number	% of total	Number	% of total
8 960	37	6 170	30	4 900	29

TABLE 2

TEACHERS ADMITTED TO FOUNDATION COURSES

	ARTS		SOCIAL SCIENCE		MATHEMATICS		SCIENCE		TECHNOLOGY	
	Number of Teachers	% of all Arts students	Number of Teachers	% of all Social Science students	Number of students	% of all Mathematics students	Number of students	% of all Science students	Number of students	% of all Technology students
1971	3 279	42.3	3 590	45.1	2 167	31.4	1 800	26.5	--	--
1972	2 038	29.6	2 551	29.5	1 493	28.2	1 284	26.1	763	19.5

These teacher-students were not evenly distributed over the four Foundation Courses available in 1971 or over the five such courses available in 1972 and 1973.*

In 1971 and 1972, for instance, the distribution of teachers over the four Foundation Courses was as shown in Table 2.

With a 'survival rate' that appears to be marginally higher than that of some other occupational groups, we find that teachers made up 42% of the students continuing in 1972 as compared with 37% of the 1971 intake.

We have estimated that in the three years 1971-73 some 5 000 teachers have been admitted to the Science or Technology Foundation Courses, and that in the current academic year (1973) there are about 5 000 teachers studying science or technology courses (including interfaculty courses with a science or technology component).

These figures establish that whatever effects Open University courses in science and technology may have on the ability of British teachers to teach science in an integrated fashion, they are not on a small scale.

2. What courses in science and technology are available or planned?

A detailed description of the courses in science and technology already available to Open University students or planned for presentation in the immediate future would take up much more space than is available in this short paper. The undergraduate course programmes of the two faculties are summarized in the chart on p.5. To understand this chart one needs to know a few basic facts about the Open University and about the faculties concerned.

The Open University offers a BA degree at two levels, Ordinary and Honours. To obtain a BA, the student must obtain six credits, of which two must be at Foundation Level. To obtain a BA (Honours), the student must obtain eight credits, of which two must be at Foundation Level and two or more must be at Third Level. There are no other restrictions on a student's choice of courses. He may choose courses from any number of faculties.

A credit involves an average student in about 360 hours of study spread over an academic year of 42 weeks, plus about 60 hours' work at a one-week residential summer school. He gains a credit on the basis of a combination between continuous assessment and an end-of-year examination. Students with previous higher educational qualifications may be awarded up to two (and in special cases three) credit exemptions. Most teachers have qualifications entitling them to two or three such credit exemptions. With the exception of the Foundation Courses and one of the third-level courses, all the science and technology courses have half-credit ratings. This offers the student a wide range of options in making up the degree programme of his choice.

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* These were, in 1971, Arts, Social Science, Mathematics and Science, and in 1972-3 the same with the addition of Technology.

OPEN UNIVERSITY UNDERGRADU
IN SCIENCE AND TECHNO

THIRD-LEVEL SCIENCE COURSES		Credits
BIOLOGY	Physiology of cells and organisms	½
	Biochemistry and molecular biology	½
	Ecology	½
	Evolutionary biology	½
CHEMISTRY	Chemistry – an integrated course	1
	Principles of chemical processes	½
	Experimental chemistry	½
EARTH SCIENCES	Internal processes	½
	Earth Sciences techniques and methods	½
	Oceanography	½
PHYSICS	Solid state physics	½
	Statistical mechanics	½
	(Astrophysics and planetary science	½)
ALL DISCIPLINES		7

THIRD-LEVEL INTERFACULTY COURSES	
SCIENCE/MATHEMATICS	Quantum theory and atomic structure
SCIENCE/MATHEMATICS/ TECHNOLOGY	Electromagnetism
SOCIAL SCIENCE/ TECHNOLOGY	People and organizations
ALL THIRD-LEVEL INTERFACULTY	

SECOND-LEVEL SCIENCE COURSES	Credits
Many combinations of courses in: comparative physiology, biochemistry, genetics, chemistry, geology, geochemistry, geophysics, geobiology (environment), Earth's physical resources, totalling 5 half-credit courses	2½

SECOND-LEVEL INTERFACULTY COURSES	
SCIENCE/TECHNOLOGY	Solids, liquids and gases
	Optics, images and information
	Principles of chemical processes
TECHNOLOGY/SCIENCE	Introduction to materials
	Electromagnetics and electronics
MATHS/SCIENCE/ TECHNOLOGY	Elementary mathematics for science and technology
	Mechanics and applied calculus
SOCIAL SCIENCE/SCIENCE	Fundamentals of psychology
TECHNOLOGY/ SOCIAL SCIENCE	Urban development
SCIENCE/SOCIAL SCIENCE/ TECHNOLOGY	Biological bases of behaviour
TECHNOLOGY/SCIENCE/ SOCIAL SCIENCE	Technology and human ecology
ARTS/SCIENCE/TECHNOLOGY	Science and the rise of technology since 1800
ARTS/MATHS/SCIENCE/ TECHNOLOGY	Science and belief (from Copernicus to Darwin)
ARTS/SOCIAL SCIENCE/ TECHNOLOGY	Art and the environment
TECHNOLOGY/MATHEMATICS	Computers
MATHS/SOCIAL SCIENCE/ EDUCATION/TECHNOLOGY	Statistics
ALL SECOND-LEVEL INTERFACULTY	

SCIENCE FOUNDATION COURSE	Credit
	1

MATHEMATICS FOUNDATION COURSE

ERSITY UNDERGRADUATE COURSES
SCIENCE AND TECHNOLOGY

-LEVEL INTERFACULTY COURSES		Credits
NCE/MATHEMATICS	Quantum theory and atomic structure	½
NCE/MATHEMATICS/ NOLOGY	Electromagnetism	½
AL SCIENCE/ NOLOGY	People and organizations	½
THIRD-LEVEL INTERFACULTY		1½

ND-LEVEL INTERFACULTY COURSES		Credits
ICE/TECHNOLOGY	Solids, liquids and gases	½
	Optics, images and information	½
	Principles of chemical processes	½
NOLOGY/SCIENCE	Introduction to materials	½
	Electromagnetics and electronics	½
S/SCIENCE/ NOLOGY	Elementary mathematics for science and technology	½
	Mechanics and applied calculus	½
AL SCIENCE/SCIENCE	Fundamentals of psychology	½
NOLOGY/ AL SCIENCE	Urban development	½
CE/SOCIAL SCIENCE/ NOLOGY	Biological bases of behaviour	½
NOLOGY/SCIENCE/ AL SCIENCE	Technology and human ecology	½
SCIENCE/TECHNOLOGY	Science and the rise of technology since 1800	½
MATHS/SCIENCE/ NOLOGY	Science and belief (from Copernicus to Darwin)	½
SOCIAL SCIENCE/ NOLOGY	Art and the environment	½
NOLOGY/MATHEMATICS	Computers	½
S/SOCIAL SCIENCE/ ATION/TECHNOLOGY	Statistics	½
ECOND-LEVEL INTERFACULTY		8

THIRD-LEVEL TECHNOLOGY COURSES	Credits
Systems modelling	½
Human factors and systems failures	½
Manufacturing systems	½
Electronic design	½
Electronic materials and devices	½
Control	½
Telecommunication systems	½
Materials processing	½
Designing materials	½
Materials under stress	½
Fluid dynamical modelling	½
The built environment	½
Engineering design	½
ALL THIRD-LEVEL TECHNOLOGY	6½

SECOND-LEVEL TECHNOLOGY COURSES	Credits
Engineering mechanics	½
Systems behaviour	½
Instrumentation	½
Man-made futures - design and technology	½
Systems management	½
Designing the future	½
ALL SECOND-LEVEL TECHNOLOGY	3

S FOUNDATION COURSE	Credit
	1

TECHNOLOGY FOUNDATION COURSE	Credit
	1

No formal educational qualifications are required for admission and in fact the students who have been admitted to, and have obtained credits in Open University Foundation Courses have had qualifications ranging from University Degrees down to none at all.

Broadly speaking, in science and technology, a second-level course is one which has o Foundation Course as prerequisite and a third-level course is one which has a second-level course as prerequisite.

The Science Faculty is staffed in four discipline areas: biology; chemistry; Earth sciences; and physics.

The Technology Faculty is staffed in five discipline areas: design; electronics design and communication; engineering mechanics; materials science; and systems.

Thus the courses offered are mainly in these disciplines or in combinations of them. In addition to the courses produced entirely by the staff of one or other faculty, there are, as the chart on p. 5 shows, a number of interfaculty courses. These are produced by staff of two or more faculties. All courses, whether 'single-faculty' or interfaculty, are produced by Course Teams. For information about the Course Team approach to course production in the Open University and about the systems approach to course design, the reader is referred to the paper by A.R. Kaye and M.J. Pentz* .

It will be apparent that with the array of second and third-level courses shown in the chart, a student hos a very wide range of choice of courses, even if he restricts himself to the science/technology areo. Many students with an interest in science (particularly physics) or technology are likely to be interested in mathematics. Apart from the Mathematics Foundation Course (included in the chart to emphasize this point) there are several higher-level mathematics courses that would be useful to such students. Large numbers of students studying the Psychology and Biological Bases of Behaviour courses have in fact taken the Social Science Foundation Course, rather than the Science Foundation Course; many have taken both. Smaller, but not insignificant, numbers of students are opting for various Arts/Science or Arts/Technology combinations. There is no doubt that a teacher wishing to equip himself with a broad range of science-based courses so as to enhance his ability to teach integrated science will find thot the Open University course programme offers him plenty of scope.

At the other extreme, many students - indeed the majority, on the information we have - are interested in an Honours degree with the maximum possible concentration of a particular discipline. As will be evident from the chart, such a student could choose second and third-level courses so as to obtoin between three ond four out of eight credits essentially in a single 'discipline', such as biology or chemistry. A number of British Universities offer 'General Honours Degrees' in which the single-discipline content is about half. Thus on Open University student can, if he wishes, obtain a very similar qualification to these.

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* Integrated Multi-Media Systems for Science Education which achieve a Wide Territorial Coverage, UNESCO, New Trends Series, Paris 1973.

The chart shows only undergraduate courses. The Open University has a major programme of Post-experience Courses, which will include courses specificolly designed for science teachers. One such course, 'Technology for Teachers', is already in preparation and a course on science teaching methods intended primarily for teachers of integrated science in secondary schools, is at the planning stage.

3. What are the integrative features of Open University science and technology courses?

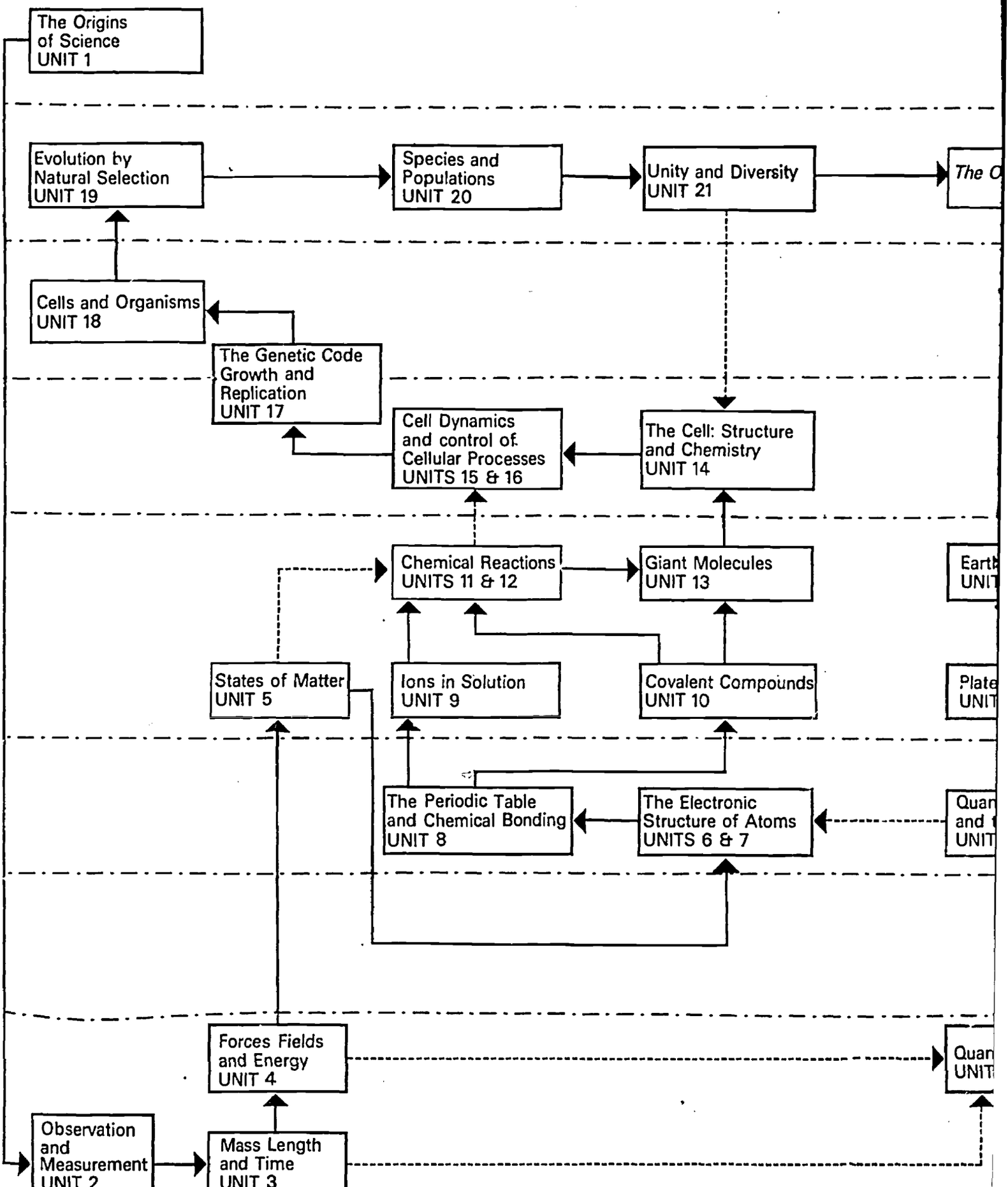
It seems self-evident that Open University courses can contribute to the education of teachers of integrated science in two ways. One way is to provide the teacher with something to integrate. If he has only learned biology, he can hardly be expected to teach biology and chemistry and physics and Earth science, whether 'integrated' or not. The other way is to offer him courses of study which are themselves 'integrated'.

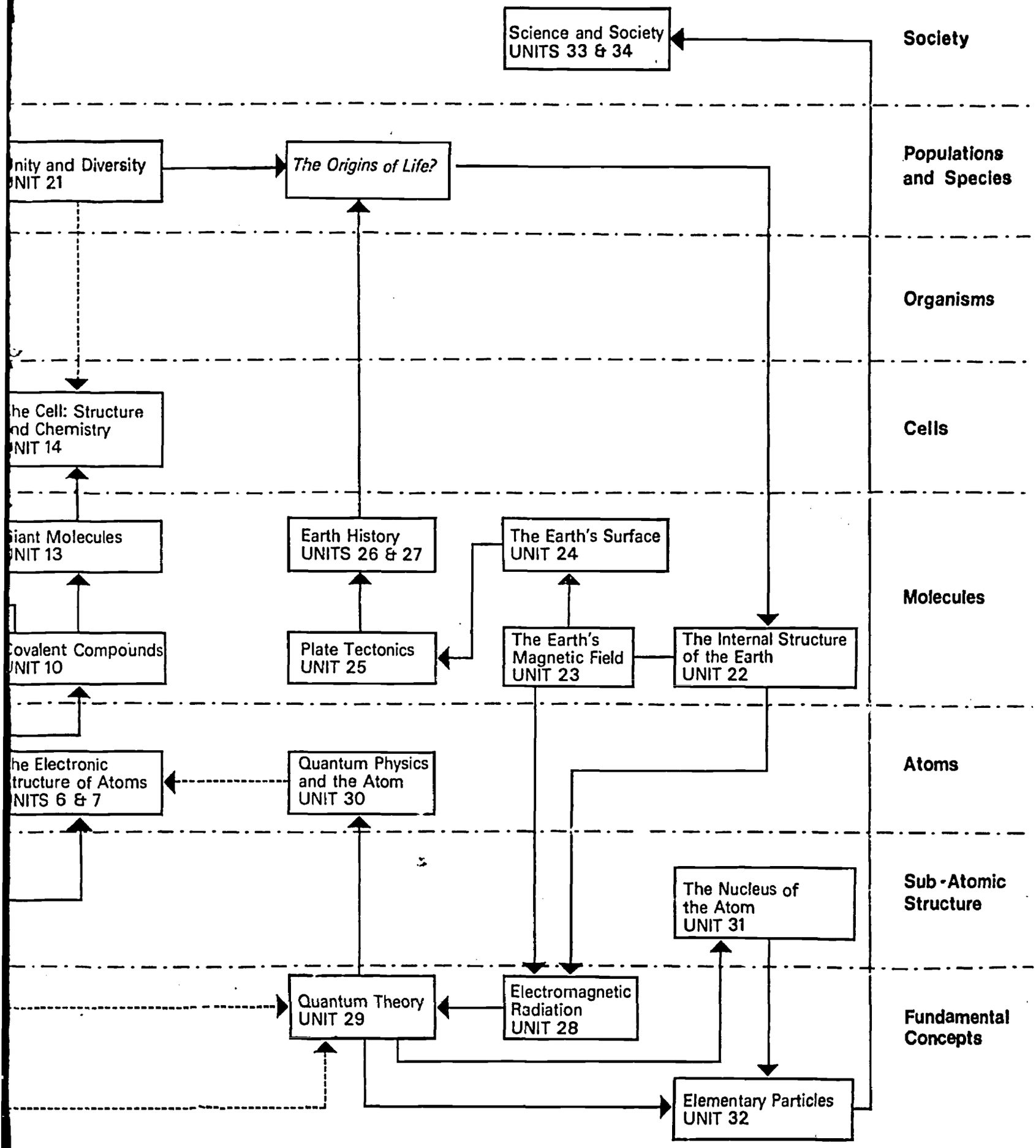
Presumably the papers to be discussed in the second plenary session will clarify the concepts of integration and integrated science. The concept of 'integration', as it has been applied to Open University science and technology courses, can best be illustrated by taking a closer look at the structure of the Science Foundation Course. See the chart on p. 8.

The opening paragraphs of the Introduction and Guide to the Science Foundation Course read as follows:

> 'One of our aims in designing this Course was that it should be an integrated multi-disciplinary course, with contributions from physics, chemistry, biology and Earth science, but linked together in such a way as to demonstrate the unity of science as well as its diversity. We try to show what is common to all the disciplines as well as what is special to each. This has seldom been done before at first-year undergraduate level.
>
> Another aim was to teach science in its social context - to bring out clearly the relationship between science and society. Again, this is breaking new ground. A few universities in Britain offer special courses about Science and Society, but none attempt to teach the main science courses themselves in this way.'

We sought to achieve these aims by giving the Course an internal structure which would emphasize the inter-relationships and internal unity of science by making as explicit as possible the historical roots and social relations of science. Thus, we begin in the first Unit of the Course by tracing the emergence of science and scientific method in man. We see science as a human activity developing within a particular technological and social context and interacting with it. Science depends on tools which are themselves extensions of man's senses of touch, sight and hearing, and the use of these tools, or instruments, for observation and experiment is the basis of the scientific method.


The Origins of Science UNIT 1
Evolution by Natural Selection UNIT 19
Species and Populations UNIT 20
Unity and Diversity UNIT 21
Cells and Organisms UNIT 18
The Genetic Code Growth and Replication UNIT 17
Cell Dynamics and control of Cellular Processes UNITS 15 & 16
The Cell: Structure and Chemistry UNIT 14
Chemical Reactions UNITS 11 & 12
Giant Molecules UNIT 13
States of Matter UNIT 5
Ions in Solution UNIT 9
Covalent Compounds UNIT 10
The Periodic Table and Chemical Bonding UNIT 8
The Electronic Structure of Atoms UNITS 6 & 7
Forces Fields and Energy UNIT 4
Observation and Measurement UNIT 2
Mass Length and Time UNIT 3


Science and Society
UNITS 33 & 34
Society
nity and Diversity
NIT 21
The Origins of Life?
Populations and Species
Organisms
he Cell: Structure
nd Chemistry
NIT 14
Cells
iant Molecules
NIT 13
Earth History
UNITS 26 & 27
The Earth's Surface
UNIT 24
Molecules
ovalent Compounds
NIT 10
Plate Tectonics
UNIT 25
The Earth's
Magnetic Field
UNIT 23
The Internal Structure
of the Earth
UNIT 22
he Electronic
tructure of Atoms
NITS 6 & 7
Quantum Physics
and the Atom
UNIT 30
Atoms
The Nucleus of
the Atom
UNIT 31
Sub-Atomic Structure
Quantum Theory
UNIT 29
Electromagnetic
Radiation
UNIT 28
Fundamental Concepts
Elementary Particles
UNIT 32

Our consideration of the nature of scientific method leads us to look into the problems of experimentation, deduction and induction, hypothesis-making and theory. The nature of the 'laboratory' and the limitations of scientific method and technique are also discussed. And in the final two Units of the Course we introduce two case studies which show what can be the social implications of scientific decisions. One is the story of nitrogen fixation and the other is that of nuclear energy. These case studies raise once again the relations between science, technology and society which were discussed, briefly, in Unit 1. We see that the relations between them are crucial to the development of all three; each affects the others. It is in this context that we examine the making of scientific choices at the levels of the individual scientist in the laboratory, the scientific administrator and the politician. It becomes apparent that the scientist has a responsibility to society and that society has a responsibility for science.

In parallel with the whole Course, and intended as a further integration device, is an essay on the Historical Roots of Present-Day Science, specially written for the Course by J.R. Ravetz. This essay 'takes off' from Unit 1 and describes a sort of parabola, bridging the Course and rejoining it in Unit 33. But it is a bridge with supports firmly based on the Course material and there are many references back to the main Course from the essay as well as links out to it from the main Course.

Through this essay, we aimed to provide the student with a different sort of history than that given in many conventional science textbooks, in which one often reads of the history of science as if it were the activity of a series of great men, working in isolation from the society which surrounds them, and unaffected by the social and political currents of their time. The intention of this essay is to correct this balance, to show the way in which, throughout its history, the intellectual development of science, the establishment of an ordered vision of the world, rational and interlocking, which forms the main substance of our Foundation Course, has been affected by, and has in its turn affected and changed these social currents.

The primary aim of the Technology Foundation Course is to explain what technology is, how it operates and how it interacts with the life of the community. Thus, it too is concerned with the internal logic and the external relations of the subject.

Inasmuch as the history, ideology and social relevance of science derive from the threefold interaction between science, technology and society, it seems plausible to suggest that a course in technology, if it is properly designed, could be of value to the teacher of integrated science.

Many of the second-level science and technology courses that have been produced in the Open University so far have similar characteristics to the Foundation Courses - they are multidisciplinary in content, integrative in approach and relate the subject to the social context.

It may thus be concluded that science and technology courses of the type being taught in the Open University could make a significant contribution to the education of teachers of integrated science. Large numbers of teachers are studying these courses. Whether their studies do in fact affect their abilities to teach integrated science is a matter of research. This research has yet to be undertaken.